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The Thermo- and Magnetogalvanic Phenomena in Nanohybrid Clathrates and their Practical Application

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There are formed structures GaSe(InSe) <organic phase>. The changes in the properties of the structures at the formation them in a magnetic or electric field, as well as under light, were shown. According to impedance spectroscopy and thermally stimulated depolarisation methods such structures were investigated. Changes in thermally stimulated depolarisation and polarization properties after 5 and 15 min. of ultra-sound processing of clathrates were studied. Conditions under which the existing structure can be used as quantum batteries were found.

Keywords: Nanostructures, Intercalation, Clathrates, GaSe, InSe, Organic Phase, Quantum Battery.

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1. INTRODUCTION

Recently formation of heterostructured inorganic/inorganic, inorganic/organic and bio/inorganic nanocomposite materials compels attention like a way of obtaining structures with wide range of new, unknown properties. However, the known methods of their production, such as vacuum deposition, photolithography, synthetic Langmuir-Blodgett technique have some reservations related to the limited variability in the choice of a variety of heterologous ingredients and problematic synthesis of host-guest structures [1, 2].

2. EXPERIMENTAL DETAILS

Intercalation method of forming intercalated heterophase nanostructures such as configuration GaSe (InSe) <OP> (OP-organic phase) was proposed by us. For this purpose, three-stage scheme of intercalation crystal-engineering was applied (see Fig. 1). As can be seen, this scheme allows carrying out the synthesis of nanostructures in external physical fields of single or combined action.

At the first stage sodium nitrite is introduced in the original matrix by direct exposure method in its melt of semiconductor single crystal at the temperature of 300^{0}C during 5 ÷ 10 minutes. As a result of n-stage ordering [3, 4] the distance between the layers increases significantly. The next step was deintercalation of sodium nitrite from the crystal by its extraction during the 24-hour five times cycle and drying at a temperature of 110^{0}C and reduced pressure. Deintercalated matrix weakened by Van der Waals' bonds and modified inside of crystal force fields became suitable to macromolecules introduction. Therefore, at the third stage the organic content was encapsulated in the extended crystal lattice by direct exposure at room temperature during 48 hours in its saturated solution or melt.

Impedance measurements along the crystallographic C-axis were made in the 10^{-3}-10^6 Hz frequency range using the "AUTOLAB" ("ECO CHEMIE", Netherlands) measuring complex, equipped with FRA-2 and

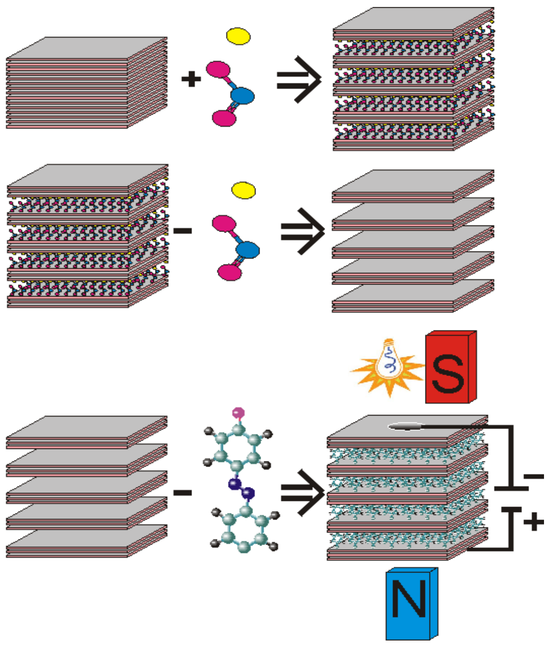

Fig. 1 – The stages of formation of multilayer heterophase nanostructures

GPES computer programs.

3. RESULTS AND DISCUSSION

There are established that depending on the synthesis conditions substantially changes current-passage regularities, polarization and charge-storage properties. Fig. 2 shows that this is due to largely different energy topology of impurity states. Thus in most cases the guest component forms coordinating defects with negative correlation energy, which form a quasi-continuous spectrum of localized states in the bandgap below the Fermi level. It is shown that the synthesized inorganic/organic nanohybridized N-barrier structures under certain conditions of their synthesis can find unique practical application.

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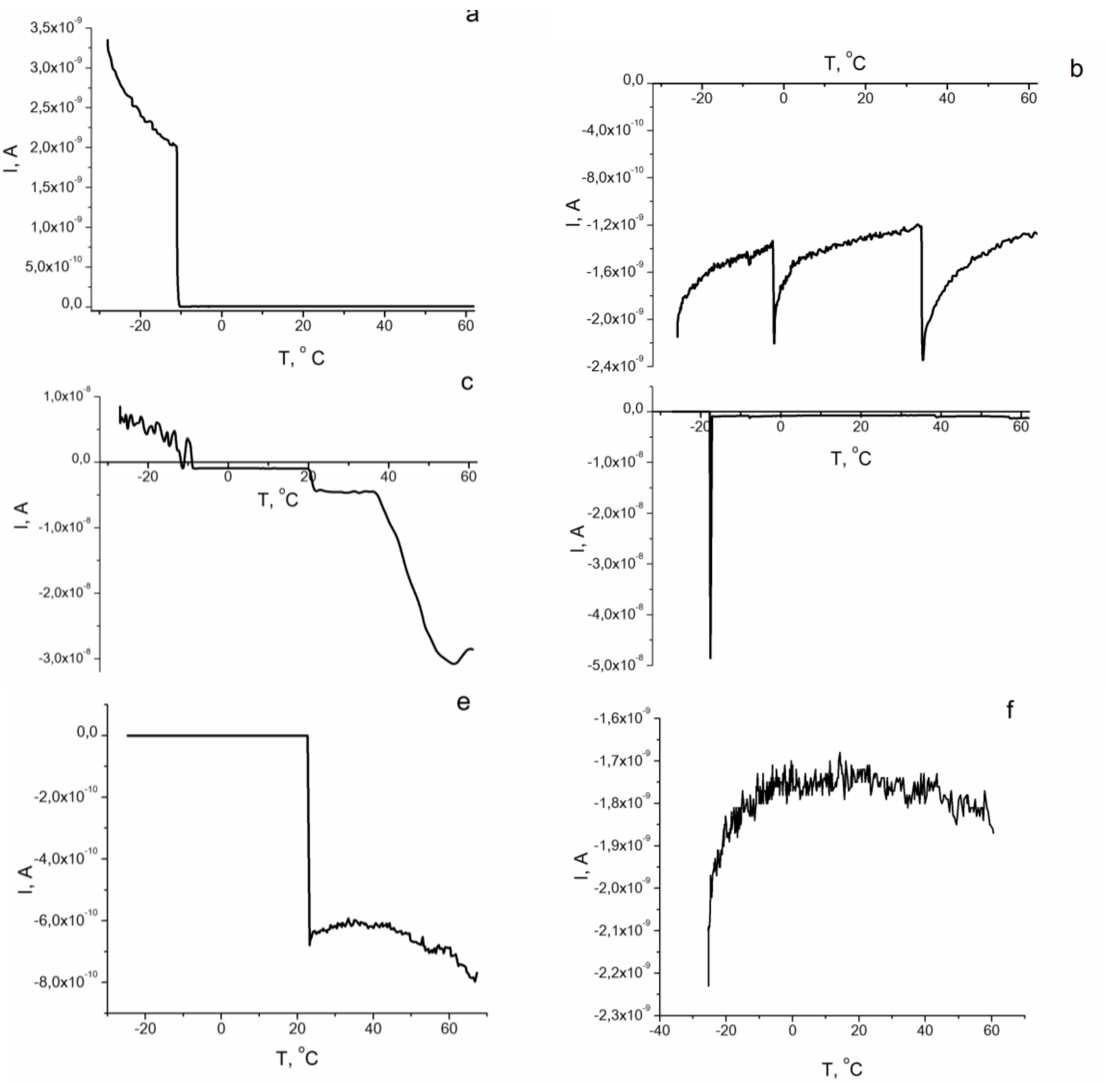

Fig. 2 – Spectra of thermostimulated discharge for InSe<CS(NH_2)$_2$>, synthesized under normal conditions (a), in the magnetic field (b), under the light (c) and in the electric field (d). (e) and (f) is InSe<CS(NH_2)$_2$> synthesized in a magnetic field and after 5 and 15 min. of ultra-sound irradiation, respectively

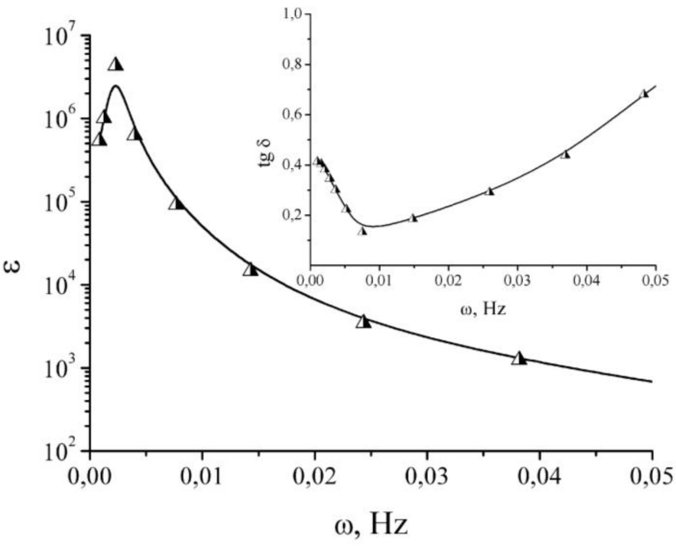

Fig. 3 – Infra-low-frequency dependence of the dielectric constant and the dielectric loss tangent (inset) for GaSe<CS(NH_2)$_2$>, synthesized under illumination. Measurements is in the magnetic field

First, due to shielding of the electret polarization by charge carriers such structures can be used for photo-electret generate electricity by photo-excited emission of electrons from asymmetric potential wells.

Second, the accumulation of charges at interfaces under the condition of interference blockade of resonant electron tunneling and large Thomas-Fermi screening radius of sub-barrier carrier opens up the possibility of accumulation of electrical energy at the quantum level and create a quantum batteries. In this case, the impedance response will consist of a combination of low (<1) electrical loss tangent and high value of the dielectric constant. Analysis of the impedance spectra of these positions among the synthesized nanohybrides found this behavior in GaSe<$CS(NH_2)_2$>, formed under light, and put in a magnetic field (Fig. 3).

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